DOE Nanoscale Science Research Centers Approach to Nanomaterial ESH

Steven Hoey CSP

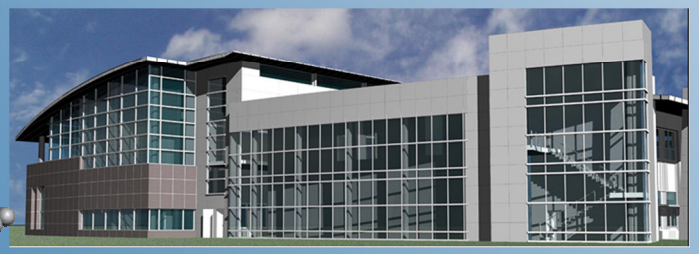
November 15, 2007

hoey@bnl.gov

Center for Functional Nanomaterials

Brookhaven National Laboratory

AN INTERDISCIPLINARY ENVIRONMENT FOR NANOSCIENCE RESEARCH



BROOKHAVEN NATIONAL LABORATORY

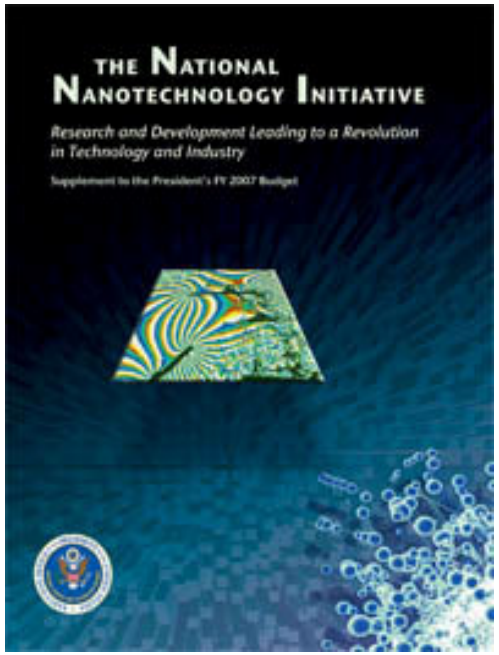
Office of Science U.S. Department of Energy

Agenda

- Description of the Nanoscale Science Centers (NSRC's)
- NSRC's *"Approach Document to Nanomaterial ESH" best practice document*
- Risk Communication
- Summary

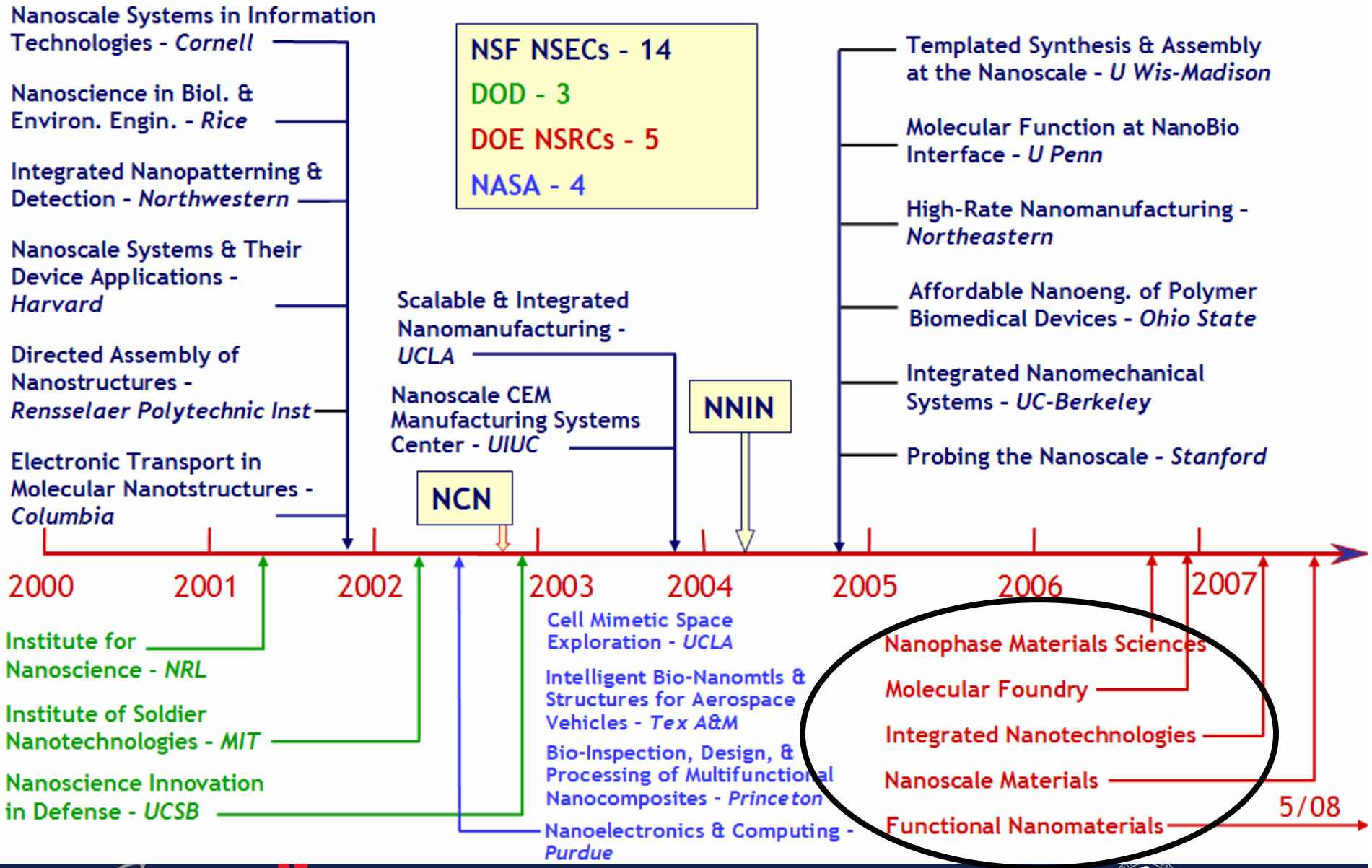
What are the NSRCs?

- The Nanoscale Science Research Centers funded by Office of Science (SC) as DOE's contribution to National Nanotechnology Initiative (NNI).



- The NSRCs are scientific user facilities
  - Designed and built beginning approximately 2002 - present
  - Conventional facilities completed
  - Instrument installation and commissioning underway or complete
  - Some level of user operations underway
  - Research and Development - small scale

NNI Centers and User Facilities



NSRC Approach Document Purpose

- Provide guidance that will help the NSRCs develop site-specific controls to protect workers and the environment.

- Help ensure that unwarranted assumptions are not made about the risks posed by nanomaterials.

- Offer reasonable guidance for:
  - Managing the uncertainty associated with nanomaterials whose hazards have not been determined and
  - Reducing to an acceptable level the risk of:
    - Worker injury,
    - Worker ill-health and
    - Negative environmental impacts.
- Promote consistency in policy and procedures between the NSRCs.

DOE Secretarial Policy

DOE recognized the importance of working safely with nanomaterials and issued a policy requiring all laboratory work be conducted in accordance with said policy.

All work with nanomaterials must be conducted in a safe and responsible manner that **protects workers, the public and the environment**.

Stay abreast of current research and guidance; ensure **best current knowledge is applied to ID and Control hazards from nanomaterials**.

DOE will **Adopt and Implement** existing and future **best ESH practice** (Consensus and/or Regulatory Standards). Apply existing related ESH requirements.

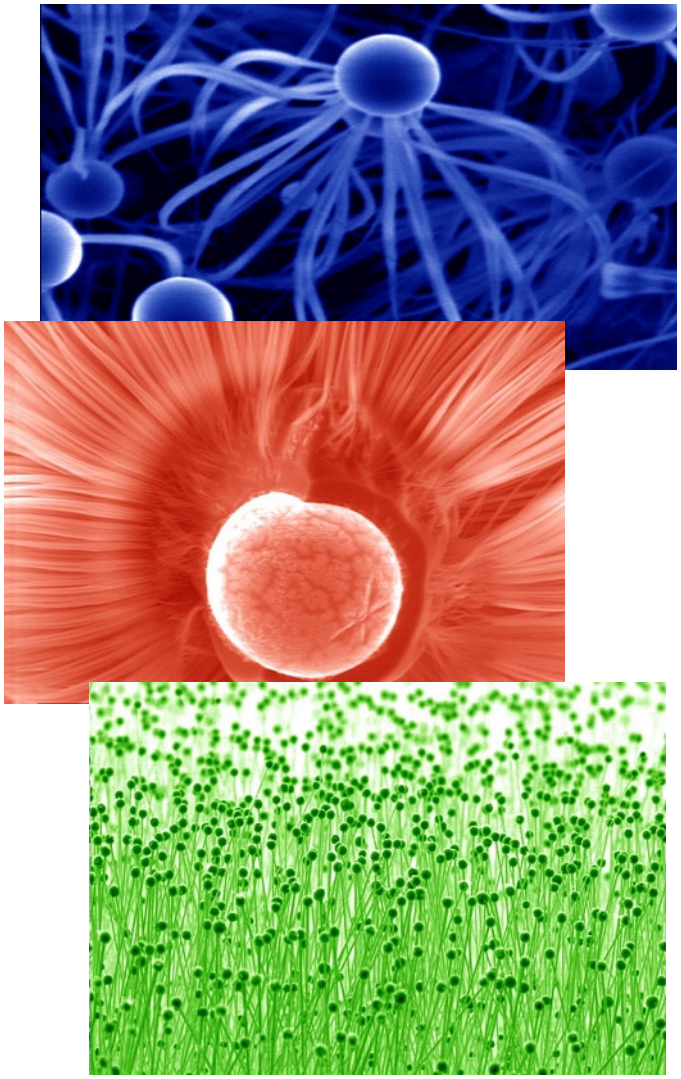
Nanomaterials - Unknown Risks

Some nanomaterials pose potential ESH concerns because they behave unconventionally;

- Toxicology is not well understood
- Acute and chronic effects in the body not identified
- Exposure standards do not exist
- Some nano materials are more reactive
- Detection methods are limited for the nano range
- Fate in the environment is not well understood

Toxicity – Emerging Information

- Depends on chemistry, morphology, surface charges, etc.
- Probably relates to particle surface area especially for insoluble/low soluble
- Preliminary Research has shown:
  - Increased inflammatory response (in vivo)
  - Translocation to target organs (rodents)
  - Allergic asthma like symptoms
  - Aggravate symptoms of pneumonia
  - Cardiac effect-2 days later



Managing Risks from Nanomaterials

- Managing unknown risk is not a new phenomena in an R&D environment, ESH approach is well tested:
  - Make conservative assumptions about risk, (treat materials as if toxic or hazardous until proven otherwise)
  - Measure the material, (using best available methodologies-establish background)
  - Establish the most effective available controls. (best practices)

Foundation - "Precautionary Principle"

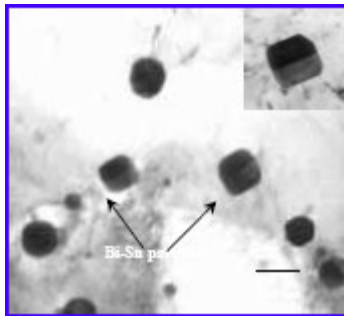
In conformance with the general principle in the National Research Council's *Prudent Practices for Handling Hazardous Chemicals in Laboratories*, engineered nanomaterials will be treated as though they are a toxic and otherwise hazardous material until empirical evidence shows otherwise.

"Approach to Nanomaterial ES&H" (Scope)

1. Introduction
2. Conceptual Foundations
3. Controls for R&D Laboratory Operations
4. Verifying Program Effectiveness
5. Transportation of Nanomaterials
6. Management of Nanomaterials-Bearing Waste Streams
7. Management of Nanomaterial Spills
8. Example Industrial Hygiene Sampling Protocol

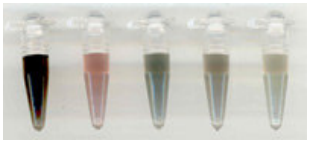
Control Methodology

- Use Work Planning to define risk and controls
- Use Good Work Practices, e.g., substitution, Engineering controls, std lab controls, good housekeeping & sanitation
- Apply Controls in a Graded Approach



Embedded Nanostructures
(Nanoscaled tin-bismuth alloys embedded in aluminum matrix)

Fixed on a matrix
(thin films on silica)



Suspended in Liquids
(nanotubes in water)

Dry dispersible, agglomerates or aggregates
(SWN powder)

LOW RISK → HIGH RISK

Engineering Controls

- In general, standard control techniques such as local exhaust ventilation systems are considered to be effective for capturing airborne nanoparticles

Snorkel Exhaust

Hoods

HEPA recommended for dispersables

Other engineering controls…

Portable HEPA

Glove Box & Bag

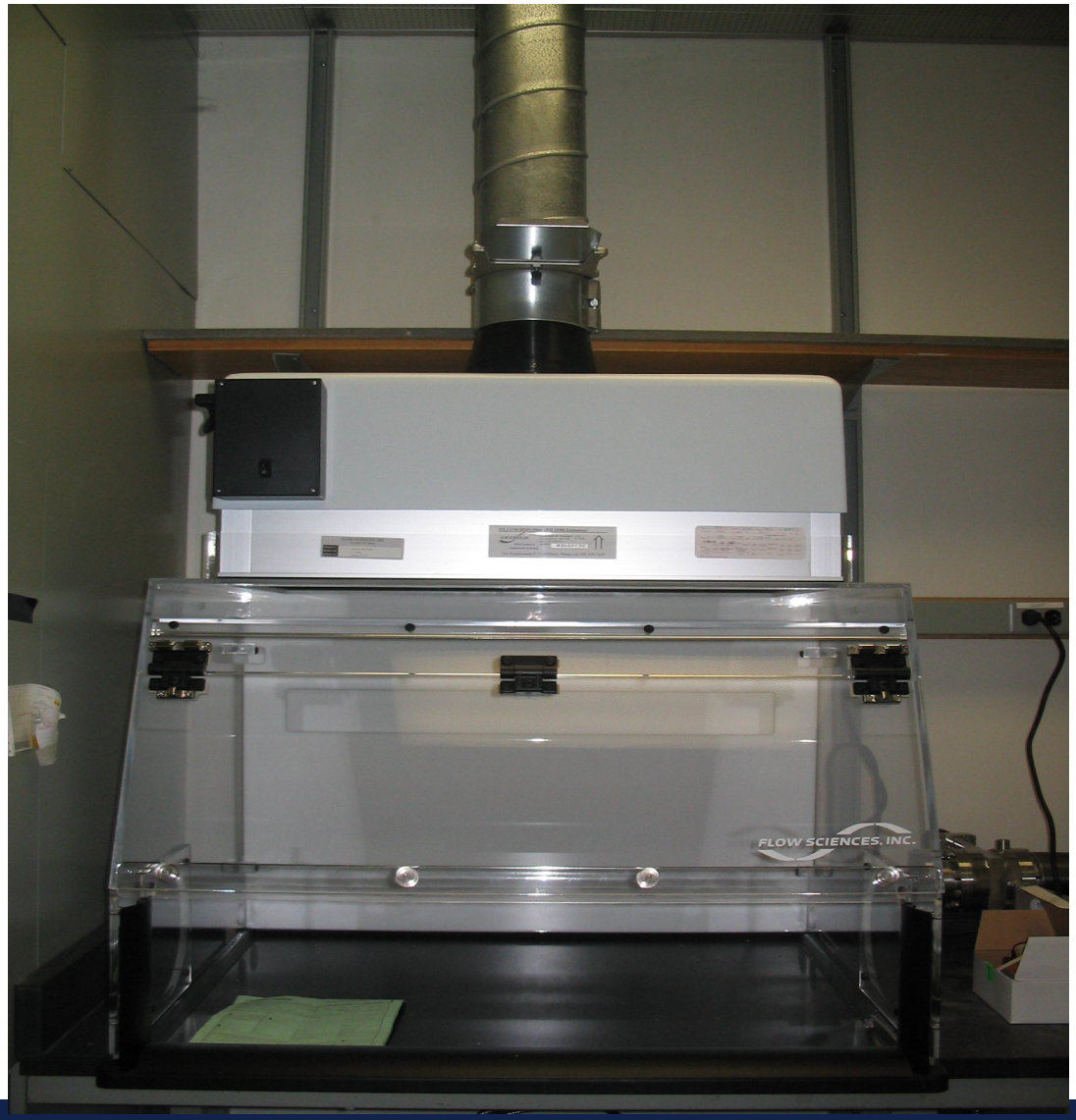
Bubbler

A documented hazard analysis is required before using another method.

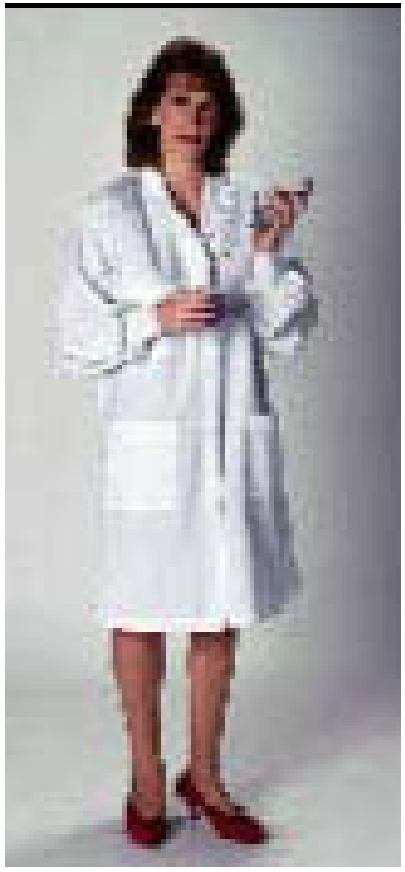
Other engineering controls…

HEPA Filtered Enclosure

Exhausted to Building Exhaust System



Exposure Control-PPE



- **Dermal Exposure (Gloves & lab coats)**
  - Follow lab standard best practices. (polymer gloves e.g., nitrile)

Safety Glasses

Respirators & Filters

- PPE that protects against gasses should be effective. (minimum half-mask P-100 cartridge)

Identify Potentially Exposed Workers

- Identify “nano-particulate workers” those who;
  - Handle nano-particulates that have potential to become airborne
  - Routinely spends time in area where nano-particulates have potential to become airborne
  - Works on equipment that might be contaminated with materials that could foreseeablly released during servicing.
- Keep track of N-P workers

Baseline NP Workers

- Provide nano-particulate workers with baseline physical examinations
  - Offer a baseline medical evaluation and periodic medical monitoring consisting of routine non-specific medical monitoring including, for example, urinalysis, blood chemistry, and pulmonary function.
  - If involved in any incident that results in an unexpected and/or unusually high exposure to nanomaterials, through any route of entry, examined by the home Laboratory's occupational medical clinic for a post-incident evaluation as per OSHA 1910.1450(g)(1)(i).

Baseline Labs

- Conduct workplace characterization & worker exposure assessments
  - Conduct “baseline” monitoring prior to startup and periodically thereafter
  - Use direct-reading particulate measuring devices to screen for suspect emissions and atypical conditions
  - Use more sophisticated techniques, to collect and analyze samples that will be used to characterize emissions and potential exposures.
- Approach doc contains an example of a sampling protocol (currently being used at ORNL).

Transportation

Nanomaterials 3 possible categories

1. DOT Hazmat:

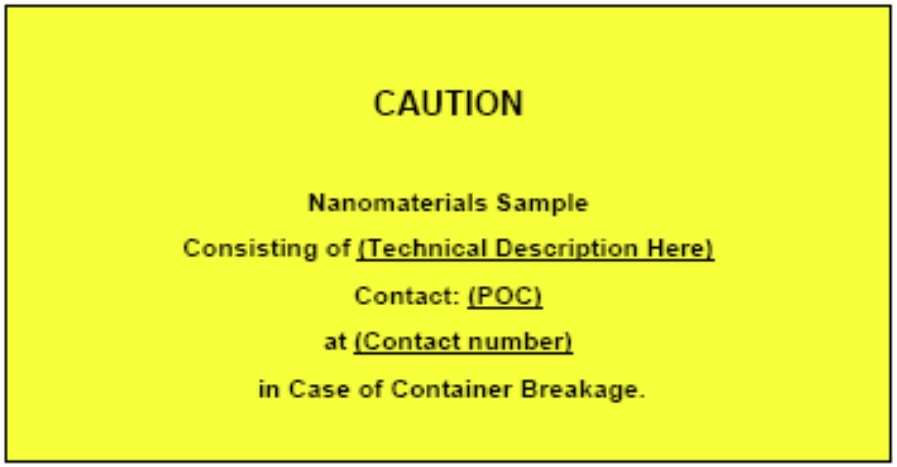
- Follow existing DOT requirements for hazardous substances that fall under 49 CFR .

2. Suspected DOT Hazmat:

- Follow DOT requirements for samples

3. Non-DOT:

- Packing Group I packaging
- Descriptions of the materials (MSDS or other information)
- Notifications to receiver of incoming shipment
- Recommend using HazMat Shipper, but not required.
- Label inner package



Waste Management

- Nanomaterial-bearing waste streams consist of;
  - Nanomaterials (e.g., carbon nanotubes)
  - Liquid suspensions containing nanomaterials
  - Solid matrixes containing, or coated with, nanomaterials that can be released to the air or leach into liquids. (This would cover contaminated PPE).
  - Commercially available chemicals containing nanomaterials.
- All nanomaterial waste is collected and characterized as either hazardous or non-hazardous (40 CFR 261.10-38 or equivalent state regs)
  - No nanomaterial waste goes to regular trash or down the drain
  - All waste containers are labeled with "contains nanomaterial" & characterization info then sent to waste management.

Spills

- Liquid or solid, procedure similar
  - Place barriers that will minimize air currents across the spill surface
  - Sticky pad at exit
  - Wet-wipe or dedicated HEPA VAC
    - Log use to identify potentially incompatible materials
  - Treat all material generated during spill clean-up as nano-bearing waste.
- **Issue: How do we determine that an impacted area is clean???**

Risk Communications

Risk Communications is a crucial aspect of any emerging technology

- A negative issue at any NSRC is an issue for all and perhaps on the entire nano industry.
- Risk Communication can have a regional "perception" and require a tailored approach
- Approach Doc does not address this… yet.
- DOE Nanomaterial Communication Group established

Risk Communications

At BNL risk communication has been shaped by historical events (reactors)

BNL established infrastructure to re-build trust and open up lines of communication;

- Community Relations Office
- Community Advisory Committee
- Executive Roundtable (local and state politicians)

•Nanotechnology communications plan in place
•Identify spokes person(s) (trained and knowledgeable)
•Community Presentations (at CAC and ER)
•Employee communication (roundtable mtgs)
•Bulletin articles (on the science and safety nano 101)
•Frequently asked questions set to help spokes people.

Summary

- Further research is necessary to quantify the risks of engineered nanomaterials (toxicity, health effects, environmental impacts) needs to be a balanced strategy that is adequately resourced.
- Standards will evolve, positive progress in nanotechnology (research and commercialization) requires standards based on solid science and engineering.
- In the interim, potential risks must be managed to protect workers, public and the environment from the impacts of nanomaterials (must be conservative and defensible)
- Don't discount the "perceived risk"
  - The NSRCs are continually updating the approach document as new information emerges invite constructive criticism.

Further Information

http://www.bnl.gov/cfn/

Hoey@bnl.gov